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ABSTRACT

This manual gives information on insects that damage crops. These fall in two categories: (1) insects with a complete life cycle such as butterflies and moths, boring insects, and beetles; and (2) those with a gradual life cycle. Also included are descriptions of leaf diseases, wilts and root and crown rots, stem cankers, fruit rots, seed and seedling diseases, smut disease, viruses and mycoplasmas, nematode diseases, and weeds. Finally, a brief explanation is given of the classes and uses of pesticides. (BB)

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Applicator Training Manual for:

AGRICULTURAL PLANT PEST CONTROL

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UNIVERSITY OF KENTUCKY · COLLEGE OF AGRICULTURE · COOPERATIVE EXTENSION SERVICE
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INTRODUCTION

Agricultural crops are grown on large acreages of diverse land influenced by several climatic conditions and subjected to infestation by various pests. The necessity of pesticides for maximum production of high quality products has been documented by research and demonstrated by experience. Products grown without the use of pesticides are generally of low quality and often are unacceptable for marketing.

Methods of pesticide application vary widely depending on the crop and the pest to be controlled. Regardless of the application technique, care should be exercised at all times to protect the crop being treated, the applicator, and adjacent areas. Crop production should be based on a well-planned management program. As part of the management program, consideration should be given to the various pesticides used during the production season and the method of application to be used. If either of these presents the possibility of contaminating adjacent non-target areas such as bodies of water, woodlands, urban areas or other crops, then another crop should be grown in that area to prevent contamination.

The key to a successful pest control program is knowing the problem. It is absolutely essential to know what pests are present in a crop before the proper pesticide can be selected for control.

Pesticides should be only a part of the overall pest control program. Other factors such as cultural practices, date of planting, selection of resistant varieties and crop rotation are an important part of a total pest control program.

PESTS

Insects

Insects are the most abundant form of animal life on the face of the earth. There are far more different species (kinds) of insects than all other animals combined. Presently, over 800,000 different species are known to man and others are being described almost every day.

Relatively few of these different species of insects are economically damaging to agricultural plants. Species of beneficial insects far outnumber damaging species.

Still, damaging insects attack crops and many of them are capable of completely destroying the crop they infest. When damaging infestations occur, they must be controlled if yield losses are to be prevented. Chemical insecticides are the most useful tool available today for controlling damaging populations of insects in crops. At the same time, other control procedures such as crop rotation, cultural practices, destruction of plant residues, date of planting and resistant varieties are being utilized in the pest management approach to insect control.

The most important step in dealing with an insect problem is identifying the pest or pests involved. To help in obtaining insect identification, life cycles and habits, as well as the best methods of control, the University of Kentucky Cooperative Extension Service has published various pamphlets available at your local County Extension Office.

Most insects that damage crops in Kentucky can be grouped into two categories of development. These categories are: insects with a complete life cycle and insects with a gradual life cycle.

1. INSECTS WITH A COMPLETE LIFE CYCLE:

These insects have 4 life stages, the egg, larva, pupa and adult. Generally, the larval (worm) stage does most of the damage. Insects in this category possess chewing mouthparts in the larval stage.

a. Butterflies and Moths

The caterpillar (worm) stage of this group does all of the damage to Kentucky crops. When hatched from the egg, they are very small, eat very little and likewise are quite easy to control. As the caterpillar gets larger, it is harder to control with insecticides. Therefore, good initial insecticide coverage is a must in order to achieve good control.

Caterpillars vary widely in color and markings. Experience and training are essential in proper identification.

Also, while a few caterpillars feed on one plant, many feed on a wide variety of crops.

(1) Foliage and Fruit Feeders

This group contains more different species of damaging caterpillars than any other. Some feed only on the foliage, others feed only on fruit, and still others feed on both. For the purposes of this manual, it is not practical t cover in detail all of the more important damaging species. The *corn earworm* has been selected as an example.

The corn earworm is also known as the cotton bollworm, tomato fruitworm, false tobacco budworm, and soybean podworm. It varies in color from light green to almost black and has a yellow stripe down each side.

Fig. 1: Corn Earworm; a. egg; b. larva; c, pupa; d. adult moth.

The caterpillar ("worm") stage lasts from 14 to 21 days but during the summer it will be nearer nearer 14 days. The entire life cycle (egg to adult) lasts approximately 30 days at this time of year.

Corn earworms feed on both the foliage and the fruit. The more important crops it feeds on and the parts damaged are as follows:

Corn - ear and whorl	Tobacco - bud and other foliage
Small grains and sorghum - head	Pepper - pod
Soybeans - pod and foliage	Okra - pod
Tomatoes - fruit	Other legumes - foliage and pods

There are many other foliage and fruit feeding caterpillars. Some of the more important species are fall armyworm, "true" armyworm, tobacco budworm, loopers, black cutworm, and tobacco and tomato hornworm.

(2) Boring and Tunneling Insects

This group contains fewer species than the preceding group but some are very important pests. Many Kentucky crops are damaged by these pests.

The length of time that these pests feed on the exterior of the plant after eggs hatch and before they enter the plant is relatively short. A properly timed insecticide application is essential to control the pest while it remains outside the plant and before it begins to tunnel. A few species are controlled by insecticides, called "systemic insecticides", that are absorbed by the plant being attacked.

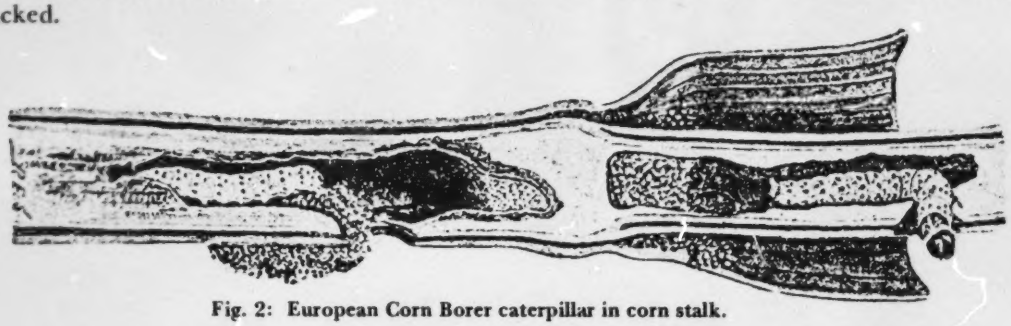


Fig. 2: European Corn Borer caterpillar in corn stalk.

The European corn borer is a good example of this group. Egg masses are laid by the adult moth on the undersurface of the corn leaf in clusters of from 5 to 50. Eggs hatch and caterpillars feed from 10 to 14 days on the exterior parts of the plant. After this time, they bore into the stalk, where they remain until they are mature at about one inch long. The head is dark brown or black and the upper part of the body is gray to pink with rows of dark spots running lengthwise. The underside of the body is cream colored. Tassels or grain heads of damaged plants often break over. In heavy infestations, their feeding may cause the plant to collapse or the corn ear to fall off.

European corn borers are important pests of corn and closely related grass crops such as sorghum and millet. European corn borers have been found on nearly all herbaceous plants large enough for the worms to enter. Their hosts include over 200 different plants such as field peas, peppers, and Irish potatoes.

Controlling this pest with insecticides is difficult. An effective systemic insecticide must be used or insecticideal sprays must be applied before the insect tunnels into plant parts.

Other boring and tunneling caterpillars include the Southwestern corn borer, peachtree borer, and several types of leaf miners.

b. Beetles and Beetle Larvae

Beetles and their larvae are important pests of agricultural crops. In most instances, both the adult and larval stages damage plants. The larvae are often called grubs or worms and the life cycles of these pests vary from less than 30 days to one or more years in length for different kinds of beetles.

(1) Beetles

Beetles usually feed on some exterior part of the plant such as leaves, stems or flowers, while larvae may feed inside the plant, on the roots, or on the outside of the plant.

The bean leaf beetle is a good example of this category. These widely-distributed leaf feeding beetles are generally of minor importance. However, with high populations they may

damage soybeans by leaf, stem and pod feeding. Diseases such as bean pod mottle virus can be spread by these beetles.

Adults are approximately 1/2 inch long and quite variable in color. They range from reddish to yellowish, with or without three or four black spots at the inner edge of each wing cover. The outer margin of the wing cover is banded in black.

The adult stage overwinters in or near crop remnants. Adults feed on the undersurface of the soybean leaf, resulting in rounded holes. When disturbed, they generally fall to the soil surface. Each female lays more than 40 eggs, deposited in groups of 12 to 14 in the soil near the base of soybean plants.

Fig. 3: Bean Leaf Beetle; a. full-grown beetle; b. pupa; c. grub. The small straight line between a and b shows the length of the full-grown beetle.

(2) Beetle Larvae

Beetle larvae are usually referred to as grubs or "worms". Larvae feed on underground plant parts, a practice which may cause plant stunting or death.

The lengths of the life cycles of these pests are variable. Most require one or more years to complete their life cycle, while others require no more than one month under ideal conditions. The bean leaf beetle larvae is a good example of a pest that damages a plant both in the larval and adult stages.

Bean leaf beetle eggs hatch and the larvae begin to feed on the roots and nodules within two weeks. Feeding on the stem just below the soil surface can also girdle the plant. In about five weeks the full grown (1/2 inch) larva forms an earthen cell and the resulting pupal stage lasts about one week. In Kentucky there are two generations per year.

Control usually consists of an insecticide application at planting. Some are controlled by insecticides applied to the soil surface after the crop is growing.

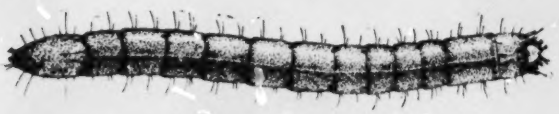


Fig. 4: Corn Wireworm

Fig. 5: White Grub

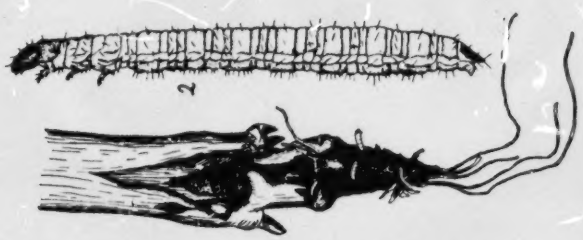
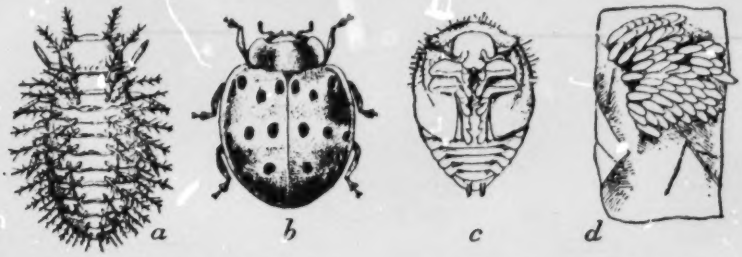


Fig. 6: Southern Corn Rootworm in root.

(3) Leaf Feeders

Many leaf feeding beetles are the adults of soil feeding larvae. Often the adult feeding is not considered to be of economic importance.

The Mexican bean beetle is an important leaf feeder. Both the adult and the larva feed on foliage. All four stages of the life cycle are found on the leaves of plants. This insect is primarily a pest of legumes.



a, larva; b, adult; c, pupa; d, eggs

Mexican bean beetle life cycle.

Control of leaf feeding beetles requires a foliar application of a recommended insecticide.

2. INSECTS WITH A GRADUAL LIFE CYCLE:

This group includes a large number of different species of several types of insects. Most of them have piercing-sucking mouthparts with a proboscis equippped in such a way that plant tissue can be pierced and juices sucked up for food. Some inject saliva during the feeding process, which causes a deterioration of the plant tissue fed upon. Some feeding damage causes a malformation of plant parts. Other of these pests, such as aphids, excrete a sticky material called honeydew. Sooty mold often grows on this honeydew on the leaf surface, reducing the penetration of sunlight and, therefore, photosynthesis.

Fig. 8: Green Stinkbug; a. mature bug; b. beak of same; c. egg mass; d. single egg; e. young nymph; f. last stage of nymph. All enlarged; b, d, more enlarged.

These insects have only three stages in the life cycle. They are the egg, nymph and adult. There is no resting stage like the pupa, which is present in insects that have four stages in the life cycle. The nymphal stage sheds the skin several times, gradually getting larger until it changes into the adult. Both nymph and adult stages can damage the plant.

Many sucking insects can be controlled by the use of systemic insecticides. All can be controlled by recommended foliar-applied insecticides. Some of these pests feed primarily on the undersurface of leaves, making good coverage essential for effective control.

Some important pests that fit into the sucking insect group are aphids (plant lice), thrips, stinkbugs, whiteflies, plant bugs, leafhoppers and spider mites (not an insect).

Diseases and Nematodes

A plant is diseased when it is continuously affected by some factor which interferes with its "normal" structure or activities. The word "continuously" excludes such things as insect injury. Plant diseases usually show some outward signs and/or symptoms of disease.

Disease is a term usually reserved for those problems caused by parasites: fungi, bacteria, nematodes, viruses, mycoplasmas and parasitic seed plants. Some disorders caused by such things as unbalanced fertility, toxic chemicals, and air pollution are often confused with diseases.

For example, certain types of spray burn look much like some leafspot diseases. In many instances it is difficult to determine the cause without several days of laboratory work.

Symptoms and signs of a disease are the basic keys to plant disease indentification. A symptom of a disease is the reaction of the host plant to invasion by the parasite or injury from the non-parasitic factor, i.e., spots on the leaves or wilting. A "sign" is physical evidence of the pathogen—visible growth of fungus spores, for example. All disease symptoms and signs are caused by an interaction between the host plant, the pathogen (parasitic causal agent) and the environment.

There are over 80,000 different parasitic diseases of plants. Of course, no crop has this many diseases. Some have only one or two common diseases; others have many more. Tobacco has over 70 different described diseases. Only a few of these commonly occur and cause economic problems, but the fact that the less common diseases do occasionally occur complicates accurate disease diagnosis. Quite frequently, a plant may have two or more diseases at the same time.

Accurate identification and diagnosis is an art as well as a science and experience is important. This outline is not intended to make anyone an expert in identifying diseases. In an outline of this type, it is impossible to cover even the major disease problems of individual crops. This discussion is to acquaint you with the general symptoms that occur as a result of disease.

Fungi are the most common parasites causing plant disease. They are microscopic (very small and can only be seen with the aid of a microscope) plants that feed on living green plants or on dead organic material. When they attack living plants, a disease results. Fungi usually produce spores which, when carried to a plant, can begin an infection. These spores may be carried from plant to plant by wind, water, insects and equipment. In order for fungus spores to begin new infections, adequate moisture and the right air temperature are required. A plant wound is sometimes also needed as an entry for the fungus. Fungus diseases are common during wet, humid seasons.

Bacteria are single-celled microscopic organisms. Some attack living plants and cause plant disease. Bacteria can be carried from plant to plant by wind, rain splash, insects and machinery.

1. LEAF DISEASES:

These diseases occur primarily on leaves, but some may also occur on stems and/or fruit. Leaf diseases are the most common diseases of most plants. They are usually controlled with fungicides, bactericides, and resistant varieties. Although leaf diseases are described under several different symptom types, keep in mind that differences are not always clearcut and there are many names for leaf diseases other than those given, a situation which can be confusing.

Fig. 9: *Helminthosporium* **Leaf Spot-Corn**

a. Leaf Spots

Leaf spots (other names: anthracnose, scab, leaf blotch, shot hole) are usually rather definite spots of varying sizes shapes and colors. There is nearly always a distinctive margin. Sometimes the spot, which may be caused by bacteria or fungi, is surrounded by a yellow halo. If caused by a fungus, there is nearly always fungus growth of some type in the spot, particularly in damp weather. This fungus growth may be tiny pimple-like structures, often black in color, or a moldy growth of spores. It is often necessary to use a hand lens or a microscope to see these structures. If the spots are numerous or close together, diseased areas may join together to form irregular areas called "blotches." The common names of leaf spot diseases may be general, such as bacterial leaf spot; descriptive, such as frog-eye leaf spot; or named after the fungus, such as *Septoria* leaf spot.

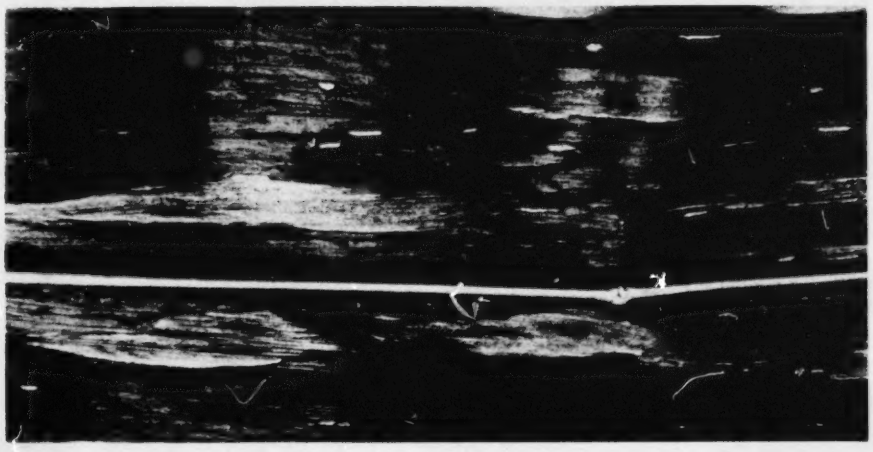


Fig. 10: Bacterial Leaf Blight-Corn

b. Leaf Blights

Leaf blights are generally larger diseased areas than leaf spots and more irregularly shaped. Usually the common name includes the word "blight" such as Southern corn leaf blight or early blight.

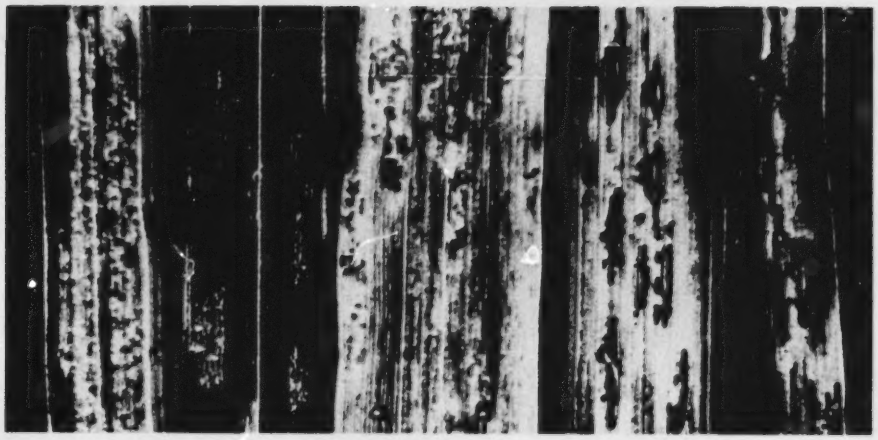


Fig. 11: Leaf Rust-Wheat

c. Rusts

Rusts often produce spots similar to leaf spots, but the spots are called "pustules." Rust pustules are bright yellow, orange-red, reddish-brown or black in color. The pustules are usually raised above the leaf surface, and, when rubbed with a white cloth, a colored deposit the same color as the pustule can usually be seen on the cloth. In severe cases, the leaf withers and dies rapidly. Some types of rust also occur on stems. Rusts are common on grains and grasses.

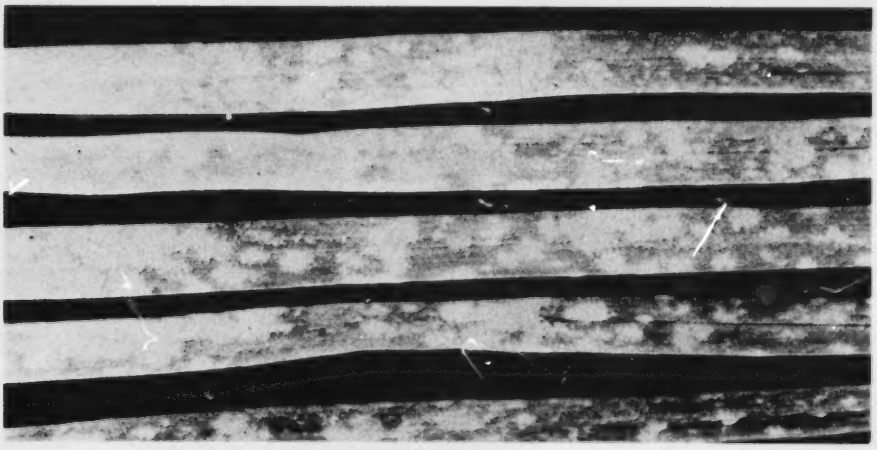


Fig. 12: Powdery Mildew-Barley

d. Powdery Mildew

Powdery mildew is a superficial, white to light grayish, powdery to mealy growth on leaves, but may also occur on stems and flowers. Affected leaves usually turn yellow, wither and die rapidly. The problem is common on cucurbic-type vegetables and on small grains.

Fig. 13: Downy Mildew "Crazy Top"-Corn

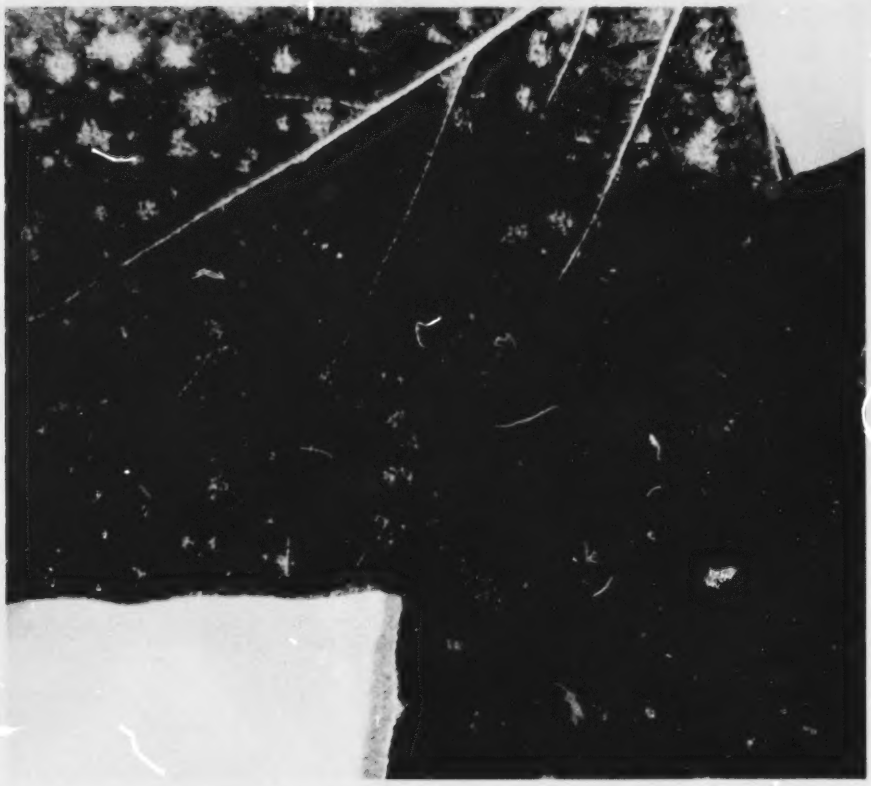


Fig. 14: Downy Mildew-Soybeans

e. Downy Mildew

Downy mildew symptoms are pale green to yellow areas on the upper leaf surface; light gray to purplish moldy growth on the under surface of the leaf. Blue mold of tobacco is a downy mildew disease. Deformed plant growth ("crazy top") may result from Downy Mildew as in the case of Sorghum Downy Mildew of corn.

2. *WILTS, ROOT AND CROWN ROTS:*

The main symptoms of these three diseases are wilting, stunting and death of plants. Close examination of such plants will nearly always allow you to determine if it is a wilt, a root rot or a crown rot. These diseases are usually soil-borne (the causal organism is already present in the soil when the host is planted) as opposed to most other diseases (except nematode diseases), which are usually spread through the air. Some of these diseases may be controlled through the use of soil fungicides and/or soil fumigants, but most are controlled with resistant varieties and cultural practices. Good controls are not available for many of these diseases.

Fig. 15: Tobacco Wilt

a. Wilts

Most diseases that are called wilts are caused by fungi—*Fusarium* and *Verticillium*—and a bacterium, Erwinia. Each parasite causes wilts on a wide range of crop plants. When a stem of a plant with one of the fungus wilt diseases is cut lengthwise, a light to dark brown streaking can often be seen in the stem. It is often difficult to determine which of these wilt diseases a plant may have. Plants with *Fusarium* or *Verticillium* wilt are usually slower growing than healthy plants and may show stunting effects before wilting occurs. The lower leaves usually turn yellow and wilt first, then yellowing and wilting slowly progress up the plant. Several days to a few weeks may elapse between first evidence of wilting and death of the plant.

Fusarium wilt is a disease of tobacco and several vegetables. *Verticillium* attacks several vegetables. Erwinia causes a bacterial wilt and blight of corn and a cucurbit bacterial wilt.

b. Crown Rots

This includes those diseases in which the causal organism attacks the plant at/or near the soil line. Crown rots are called various names such as *collar rot, stem blight, stalk rot* and *Southern blight.* Affected plants are generally, at first, unthrifty with leaves smaller and lighter green than normal. Leaves usually turn yellow and, in advanced stages of disease, wilt and die. The crown or base of the stem will be water-soaked, discolored or decayed. With some diseases, this area may dry rot and

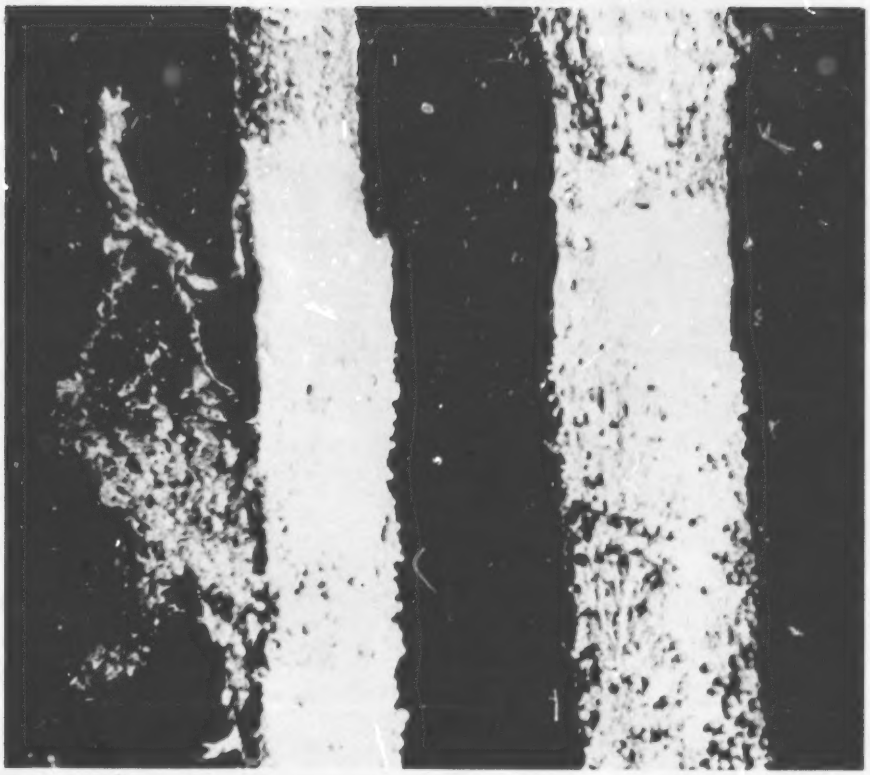


Fig. 16: Southern Stem Blight-Soybean

become shredded. A moldy growth and various colored fungus fruiting bodies often form in this diseased area. Most crops are affected by one or more of this type of disease.

Fig. 17: Corn Root Rot

c. Root Rots

Above-ground symptoms of these diseases are variable. Some plants may show wilt type symptoms and die rapidly; others may become yellow, stunted, slow growing and may not die for

some time after the first symptoms are seen. Roots are reduced in size and will be light brown to black in color, with both taproots and feeder roots decayed. Most plants are susceptible to root rots.

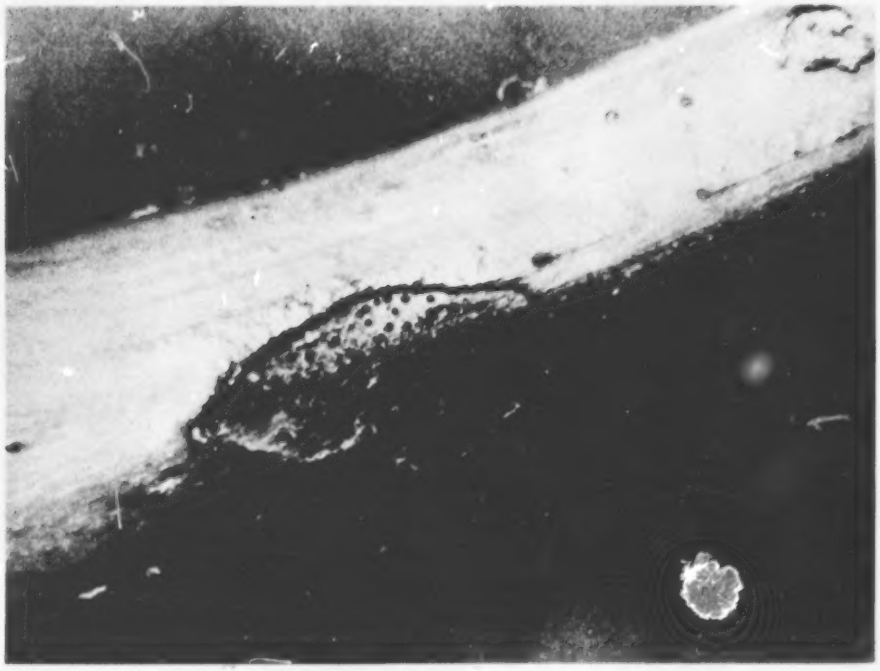


Fig. 18: Black Rot Canker-Grape

3. STEM CANKERS:

Stem cankers are localized diseased areas on main stems or branches of woody plants. Canker diseases result in a shrinking and dying of the bark tissues, which later crack open and expose the wood underneath. Cankered areas may be irregular or oval in shape with tan or gray centers. Small, black, pimple-like structures, which are fungus fruiting bodies, may form in the cankers. Cankers can enlarge and girdle the stem, causing death to the above plant parts. The parasites causing cankers usually begin infection in a wound or injury to the woody plant. Proper pruning practices and fungicide applications are used to control canker diseases.

4. FRUIT ROTS:

These diseases are caused by many different fungi and bacteria and occur on all types of fruit. The symptoms vary from a more or less superficial fungus growth on the external surface to a complete, mushy rot. These rots may be small scattered spots or involve the entire fruit. Many of these spots may be sunken below the surface and contain spores or other fungus fruiting bodies. Some types of fruit rot may cause a shrivelling of the fruit and dry rot. Fruit rot may develop while the fruit is still on the plant or in shipment and storage. Some rots are specific diseases, occurring only on a certain

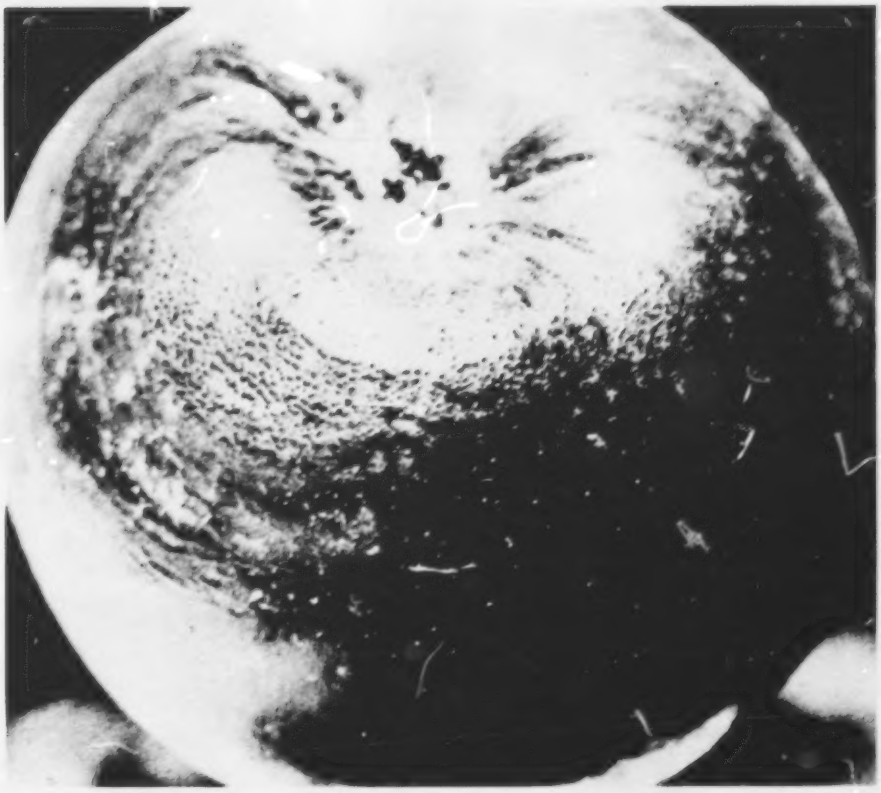


Fig. 19: Black Rot-Apple

fruit; others may occur on many different fruits. One of the most important rotting diseases is Bacterial soft rot, which occurs on almost all fruits and fleshy vegetables. This disease usually occurs only after an injury and is characterized by a rapid, mushy or watery foul-smelling rot. Fruit rots are controlled to some extent by fungicides, sanitation and proper storage conditions.

5. SEED AND SEEDLING DISEASES

By definition, these diseases occur on plants only until about one to two weeks after seedling emergence. Seed diseases are caused by fungi which may be on the seed at planting or by fungi in the soil. They are often responsible for poor emergence and thin stands. Seedling diseases occur after germination until shortly after emergence. If the disease occurs before emergence, the seedling may rot before it has a chance to get out of the soil. After emergence, seedling stems may be attacked at or below the soil line. There are two general symptoms which occur at this time, brown to reddish-brown or black cankers at the soil line, and a soft watery rot. In the first instance, if the cankers girdle the stem, the seedling falls over and dies; or, with partial girdling, the plant may continue to live, but will be stunted. In the second instance, the soft watery rot continues until the entire seedling decays. Seed and seedling diseases are most common in cool, wet soils. They are controlled by planting crops in warm soil, by fungicide seed treatments, and by use of in-furrow fungicides.

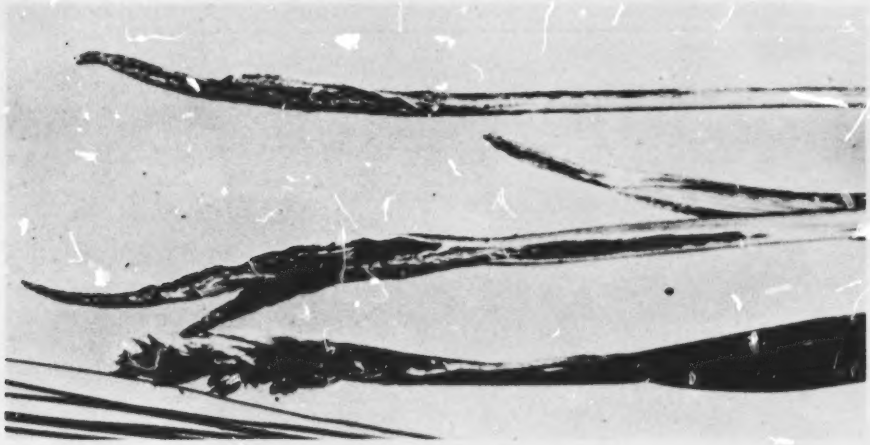


Fig. 20: Loose Smut-Barley

6. SMUT DISEASE:

The fungi that cause smut diseases attack grasses and cereal crops. The most destructive smuts attack small grains, often causing the kernels of grain in the head to be replaced by a mass of dark powdery fungus spores. Corn smut disease results in a swelling of the affected plant part with the galls produced on the plant containing a mass of dark, powdery spores.

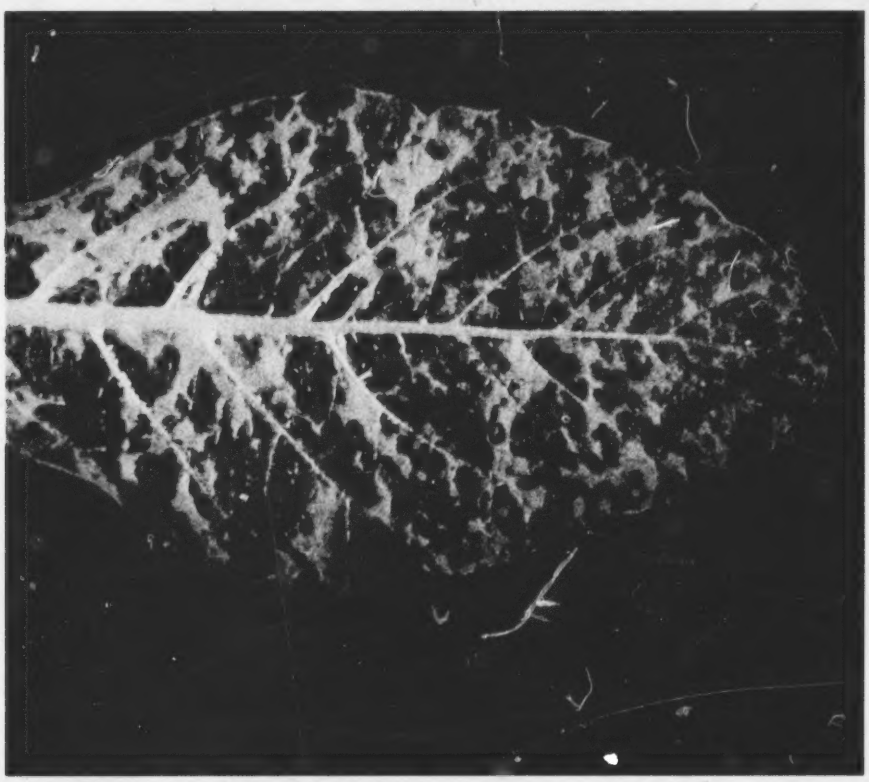


Fig. 21: Tobacco Mosaic Virus

Fig. 22: Barley Yellow Dwarf Virus

7. *VIRUS AND MYCOPLASMA DISEASES*

These parasites are the smallest of microorganisms causing plant disease. Some of the more common symptoms of virus and mycoplasma diseases are described here. *Mosaic:* is characterized by a light green to yellow leaf mottling, usually accompanied by abnormal leaf growth. *Vein banding* is noticeable from a light green to yellow band around the leaf veins which may turn dark with time. *Ring spot* causes alternating rings of light green or yellow bands with the normal green of the leaf. *Yellows* is apparent when the entire plant or some parts turn uniformly yellow. Stunting usually accompanies all of the previous symptoms, or stunting may be the only symptom. Some virus diseases do not show any visible symptoms other than a yield reduction. Many virus and mycoplasma diseases are transmitted from plant to plant by insects, some are transmitted by grafting, and others are transmitted by mechanical means. These diseases are difficult to control. Some are controlled by resistant varieties, the use of virus-free seed or planting stock, and by controlling the insects that transmit the diseases.

8. *NEMATODE DISEASES:*

Most plants are attacked by one or more types of nematodes. These parasites are microscopic worms that live in the soil and in plant roots. Nematodes cause several hundred million dollars in losses in the United States annually. It may well be that if we could accurately measure losses from these pests, losses would be even higher. This is because nematode damage often goes unrecognized or is blamed on some other problem.

Most important nematodes feed on plant roots. This directly interferes with water and nutrient uptake. Root injury causes above-ground symptoms similar to those produced by other conditions that damage the root system. Plants frequently appear to be suffering from a lack of moisture or fertilizer, even when water and fertilizer are adequate. Typical above-ground symptoms are stunting, yellowing, loss of vigor, general decline and eventual death of plants when nematodes occur in high populations.

Nematode injury in the field is rarely uniform. Symptoms usually appear in small, scattered areas and are usually more obvious when soil moisture and fertility are low.

Fig. 23: Soybean Cyst Nematode-Field Damage

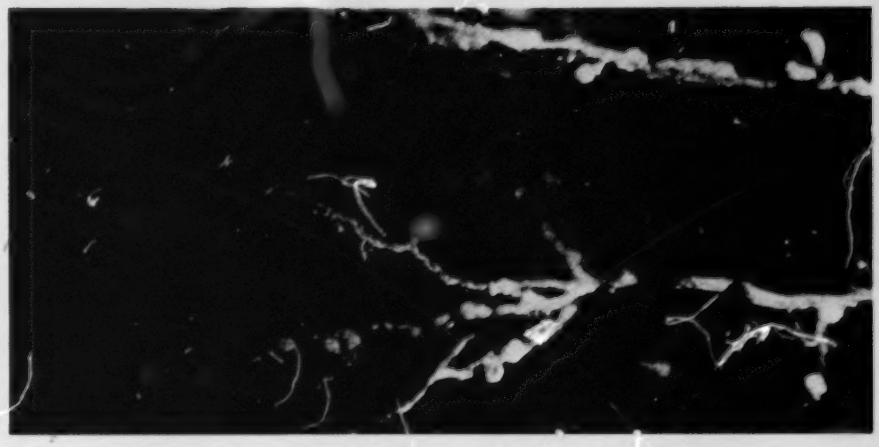


Fig. 24: Soybean Cyst Nematode-Root Damage

When nematodes are suspected, roots should always be examined and soil samples taken. Nematode symptoms on the roots depend on the type of nematode causing the injury. Usually the symptoms will be one or more of the following: galls or knots, tiny brown to black lesions, stubby roots and complete loss of feeder roots.

Many other problems can cause symptoms similar to nematodes. For this reason, samples need to be examined when nematode injury is suspected.

Nematodes are controlled with cultural practices, resistant varieties and nematicides.

Weeds and Weed Control

Weeds are a major cause of reduced crop yields. Weeds reduce yields by competition with the crop for soil moisture, nutrients and light. Not only is the quantity of yield reduced, but also the quality. Weed seed, leaves and stems present in grain lower the quality of the crop. Heavy weed growth present at harvest causes yield loss due to inefficient operation of harvesting equipment. Weeds also harbor insects and diseases.

1. *APPLICATION METHODS:*

Herbicides can be applied by several methods and at various times during the year. The following terms may be found on herbicide labels pertaining to their use.

a. Preplant Incorporated (PPI)

Herbicides in this group must be mixed into the surface soil before planting in order to achieve good weed control. Usually, herbicides that must be incorporated in the soil are highly volatile. Without incorporation, these herbicides would be lost into the air as a gas. Read and follow the herbicide label for specific instructions regarding incorporation. Examples of PPI herbicides are Treflan, Tolban, Sutan^{+} and Eradicane.

b. Preemergence

Herbicides in this group are usually applied immediately after planting. Preemergence means that the herbicide is applied after the crop seeds are planted but before the crop and weeds have emerged from the soil. This group of herbicides usually needs a rain within a few days after application to move the herbicide from the soil surface down into the top layer of the soil where most weed seeds are located. Some typical preemergence herbicides are Lasso, Lorox, AAtrex and Bladex.

c. Over-lay Treatments

This is a combination of the two types of application already discussed. A preplant incorporated herbicide is applied, the crop planted, and a preemergence herbicide is then applied. This practice is used to achieve a broader spectrum of weed control.

d. Tank Mixtures

The application of herbicides mixed together in the sprayer tank is a common practice. Herbicides are also applied in combination with liquid fertilizer. When mixing herbicides or other pesticides in the spray tank, be certain to follow label recommendations and precautions. Specific directions for tank mixing of herbicides are frequently listed on the label.

e. Post Emergence

This group of herbicides is applied after the weeds and crop have emerged from the soil. These treatments can be applied in either a broadcast or directed fashion. When applying post emergence herbicides, it is necessary to have maximum coverage of the weed with the spray solution. Surfactants are often used with postemergence herbicides to enhance control. For specific gallonages required and the amount, if any, of surfactant required, consult the label.

2. *LIFE CYCLE OF WEEDS:*

Weeds are grouped into three major categories based on their life cycles.

a. Annuals

Weeds in this category develop from seed, flower, produce seed and die in one growing season. Examples are crabgrass, foxtails, pigweed and cocklebur.

b. Biennials

Weeds in this group complete their life cycle in a two year period (two growing seasons). Often, biennials develop from seed and form a rosette during the first year (a rosette is a low-growing cluster

of leaves). During the second growing season, the stem elongates, flowers, produces seed and then dies. Examples are nodding thistle, wild carrot (Queen Anne's lace) and common mullein.

c. Perennials

Weeds of this category live for more than two years. Reproduction is by seed and/or vegetative parts. Examples are johnsongrass, trumpet creeper, and honeyvine milkweed.

3. RECOGNITION OF THE PROBLEM:

The first and most important step in an efficient weed control program is recognizing the problem weed or weeds in a particular field. It is absolutely essential to know what weeds are to be controlled before selecting the herbicide or herbicides needed.

Not all weeds respond in the same way to herbicide treatments and for this reason annuals are usually easier to control than perennials. From the standpoint of herbicidal response, weeds can be grouped into three broad categories.

a. Perennial and Biennial Weeds

Weeds in this category are generally difficult to control and require special control programs. Repeated treatments for several years are usually needed to achieve satisfactory control.

b. Annual Grasses

Weeds in this category are normally readily controlled with preplant incorporated or preemergence herbicides. However, certain weeds of this category are more difficult to control than others. For example, fall panicum is generally more difficult to control than crabgrass and therefore may require higher rates.

c. Annual Broadleaf Weeds

Some weeds in this class are easy to control with available herbicides and some are difficult to control. These easily controlled, such as pigweed and lambsquarters, have small seeds and, as a group, can usually be controlled with several of the preplant incorporated and preemergence herbicides. The hard to control weeds, such as cocklebur, jimsonweed and morning glory, have larger seeds and are of more economic importance in Kentucky.

PESTICIDES

Pesticides are used to reduce populations of damaging pests. Unfortunately, pesticides sometimes have undesirable effects on non-target organisms. Pesticides should only be used when benefits from such use are greater than the undesirable effects.

Formulations and Sources of Information

Pesticides are formulated as emulsifiable concentrates, liquid concentrates, flowable liquids, wettable powders, soluble powders, gases, dusts, granules and baits. Generally, it doesn't matter which type formulation is used as long as it can be uniformly applied to the area where it is needed, in the concentration required for pest control. In some instances, the type of formulation is important. The local county Cooperative Extension Offices have excellent sources of information on pesticides recommended, how they should be applied, safety precautions and restrictions and when to apply

them for maximum control. State Extension Specialists are available through county offices to assist with problems that cannot be handled by the local staff.

The label on the pesticide container lists the information needed in using the pesticide. It should be carefully studied before each use of the chemical.

Methods of Application

Pesticides are applied in almost every conceivable manner. Spraying is by far the most common method. However, dusting, granular application, spreading a bait and releasing a chemical that turns into a gas are other methods used. Pesticides are applied broadcast over the entire field, in bands over the row, directed to the plant bud, directed at the base of the crop plant, to the soil surface, mixed uniformly into the soil and even turned under. The type application needed depends on the pest to be controlled, the pesticide formulation and the method that has proven most effective. Often more than one pest needs to be controlled with a single application of pesticide and a compromise method may be chosen that is the best for the complex, though not as good for one or most pests present. Extension personnel can furnish information on the best method of application to accomplish the desired goal.

Insecticides

Insecticides are pesticides used to control insects. Most of the commonly used insecticides are classified as chlorinated hydrocarbons, organo-phosphates or carbamates. They are synthetic organic chemicals and are classified according to their chemical structure.

In general, chlorinated hydrocarbons have a longer residual life than the other chemicals. As a group, chlorinated hydrocarbons have a lower acute toxicity to warm-blooded animals than organo-phosphates and carbamates. They have been widely used in past years, but have been depended upon less frequently in recent years Their longer residual nature, the fact that they are stored in fatty tissue of animals, and the fact that they undergo biological magnification in natural food chains, are some of the reasons for using them less. DDT, chlordane, aldrin, dieldrin, endrin, BHC, lindane and toxaphene are examples of this group of chemicals.

Organo-phosphates are generally much less persistent in the environment than chlorinated hydrocarbons. Many of these are highly toxic to warm blooded animals and, therefore, much care should be exercised in mixing and applying them. As a group, they are probably the most commonly used insecticides today. The more commonly used organo-phosphate insecticides are methyl parathion, parathion, malathion, Di-Syston, Thimet, Diazinon, Cygon, Dasanit, Mocap, and Azodrin.

Carbamate insecticides are the newest group to gain general usage. Most of the more useful of this group are highly toxic to warm blooded animals, but are not persistent in the environment. Some examples of the carbamate group are Sevin, Furadan, Lannate and Temik.

Disease Control Chemicals

Pesticides used to control plant diseases are classified as fungicides, bactericides or nematicides.

1. FUNGICIDES

Fungicides are used to control diseases caused by fungi. Fungicides may be used as seed treatments, soil treatments, and foliar treatments. To be effective, most of these must be applied

before the disease occurs, and, as such, are protectant fungicides. A few eradicant fungicides are available, primarily those used for control of powdery mildew and scab diseases.

Fungicides can be classified as inorganic or organic.

Inorganic fungicides include formulations containing sulfur, copper sulfate, copper oxide and Bordeaux mixture. Sometimes these fungicides are not as effective as the newer organic fungicides and are often phytotoxic. Although they are still used to some extent, they have largely been replaced by organic fungicides.

Organic fungicides commonly used are maneb, zineb, captan, benomyl and chlorothalonil. These are generally used to control most leaf diseases. There are a number of others, such as dinocap (used exclusively to control powdery mildew), which have limited use for specific diseases or crops.

Fungicides as a group are not highly toxic to warm blooded animals nor do they persist in the environment for any length of time. Those fungicides that are more toxic are labeled as such.

2. BACTERICIDES:

Bactericides are used to control diseases caused by bacteria. Most inorganic copper fungicides are also bactericides. Streptomycin is the only specific bactericide, but its use is limited.

3. NEMATICIDES

Nematicides are used to control nematodes. As such, they are applied to the soil.

Fumigant nematicides are usually liquids injected into the soil, which, after injection, turn to gases. These gases diffuse throughout the soil to form a fumigated zone. Fumigant nematicides include DBCP, ethylene dibromide, dichloropropanes, methyl bromide and chloropicrin.

Non-fumigant nematicides are liquids or granules applied to the soil surface and incorporated into the soil. Some may move downward with water movement. The non-fumigant nematicides are Dasanit, Mocap, Furadan and Temik.

Nematicides are usually toxic to warm blooded animals.

Herbicides

Herbicides may be classified as:

1. SELECTIVE:

Herbicides in this group kill some plants while having little or no effect on others. The selective nature of these herbicides permits their use to eliminate weeds with little or no adverse effect on crops. Selectivity is primarily rate dependent. Other factors influencing selectivity are absorption, translocation, morphology and the physiology of plants. Some examples are AAtrex, Teflan and 2,4-D.

2. NON-SELECTIVE:

Herbicides in this group kill vegetation without regard to species. Representative examples are Hyvar, Pramitol and sodium chlorate.

3. CONTACT:

These herbicides kill or effect only the plant issues which are covered in application. They produce plant kill within a few hours to a few days after application. Examples are Paraquat and MSMA.

4. TRANSLOCATED:

Herbicides in this group are absorbed by plant foliage and/or roots and are translocated within the plant. They generally require several days to several weeks to produce plant kill.

a. Root Absorbed

Root absorbed herbicides are generally most effective if applied before weed seed germination. Generally, higher rates of these herbicides are required to control established weeds than are required for control of germinating weed seedlings. These treatments are highly effective for control of annual weeds in cropland. Some representative examples are AAtrex, Bladex, Lasso and Treflan.

b. Foliage Absorbed

Foliage absorbed herbicides are used for control of both annual and perennial weeds. Certain of the foliage absorbed herbicides are highly effective treatments for control of established perennial weeds. Examples are: Dowpon for control of perennial grass, and 2,4-D, 2,4,5-T, and dicamba (Banvel) for control of perennial broadleaf weeds.

Special Problems

1. PRE-HARVEST and RE-ENTRY INTERVALS:

Many pesticides have a minimum time requirement from the last application until harvest, a period which is known as the pre-harvest interval. The reason for pre-harvest intervals is to allow time for the pesticide to degrade, therefore preventing the occurrence of pesticide residues in the harvested crop. Pre-harvest intervals should be carefully observed to prevent harvesting an illegally contaminated product. The pesticide label contains information pertaining specifically to pre-harvest intervals.

The minimum allowable time between the application of a pesticide and the date workers may enter the treated area is known as the re-entry interval. This restriction is presently required for only a few pesticides that are highly toxic to man. Re-entry intervals should be carefully observed. Consult the label for specific information concerning re-entry.

2. PHYTOTOXICITY:

When a chemical kills or injures a plant to which it is applied, it is said to be phytotoxic (plant toxic). If the plant is a weed and the chemical is a herbicide, this result is desirable; but, usually, the word phytotoxic is used when a pesticide may injure desirable plants. Phytotoxicity may occur due to drift onto non-target plants, excessive rates, or the mixing of chemicals in a more concentrated form than is desirable.

To avoid the problems of phytotoxicity, apply chemicals within recommended rates and follow all label recommendations and precautions regarding the use of that particular pesticide.

3. RESIDUES:

The amount of a pesticide that remains after application is the residue. The ideal pesticide would be one that is residual enough to give control of a pest for the length of time needed and then break

down completely into harmless chemicals. Unfortunately, this is not the case with most pesticides. The long residual nature of chlorinated hydrocarbons is one of the main reasons they are being used less. A tolerance is set for each chemical that is registered on a crop and usually expressed in parts per million (ppm). The residue that remains on the harvested crop cannot exceed the tolerance that was set when the pesticide was registered by the Environmental Protection Agency. This has a direct relationship to the pre-harvest interval. Label recommended rates should not be exceeded because the pesticide residue may exceed the legal tolerance.

4. ENVIRONMENTAL CONTAMINATION:

The long residual chlorinated hydrocarbon insecticides are the most likely chemicals to cause contamination of the environment for an extended time period. These chemicals should be used in strict accordance with the label. If possible, avoid using a broadcast treatment over a large area, such as entire county or several counties. Before undertaking large-scale control efforts, consult governmental agencies about recommendations, precautions and restrictions.

a. Non-target Injury and Community Problems

Care should be exercised not to contaminate non-target areas when applying a pesticide. This is particularly true of food and feed crops, bodies of water, apiaries, woodlands, and urban areas. Information on the least hazardous recommended chemical to use in situations where there is danger of contamination can be obtained from county Extension offices.

Drift is probably the chief factor contributing to contamination on non-target areas. Pesticides should be applied when there is little or no wind. Under no conditions should pesticides be applied if the wind speed exceeds 10 miles per hour. Using extremely low volume and air delivery spraying systems increases the problems of drift. Some pesticides, particularly herbicides, may badly damage or completely destroy some crops if they are allowed to drift onto them. The phenoxy herbicides (2,4-D, 2,4,5-T, etc.) are examples of the type of chemicals that can be very damaging to susceptible crops such as tobacco and tomatoes.

Such precautions as spraying when there is little or no wind, using the least volatile forms of potentially harmful chemicals, using drift control agents, and the avoidance of spraying with very small particles will help prevent these problems.

b. Contamination of Soil and Water

When pesticides are used, care should be taken to prevent unnecessary contamination of the soil and adjoining bodies of water. Select the pesticide that is least likely to cause contamination problems.

For example, carefully mark each swath in order to avoid a double application. Some herbicides and long residual insecticides may have a carry-over effect if excessive rates are used. This could contaminate or destroy subsequent crops.

When bodies of water are in close proximity to the area being treated, select the pesticides that would be least likely to cause contamination of the water. Make applications when there is no wind, or when the wind is blowing in a direction that would drift any pesticide away from the water. If the area to be treated is sloping, do not apply the pesticide when heavy rains are forecast. This will prevent washing the pesticide into the water.

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